原　　著

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17. 殺虫剤に対するイエバエの抵抗性の温度係数

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抵抗性および感受性イエバエ *Musca domestica nebulo* に対し，DDT，ディールドリン，BHC を径皮的に施用し，処理後 5°, 15°, 25°, 35°C におき，致死率におよぼす温度の影響を調べた．ディールドリンは温度が上るにともなって致死率が増したが，DDT と BHC では，この逆で温度の上るにともなって致死率が減った．抵抗性，感受性ともにこの傾向は同じであった．このように殺虫剤の種類によって温度の影響が異なるのは，遺伝的な生理的抵抗性とイエバエの活動性とが，殺虫剤の活性を高めたり低めたりする二つの要因であると推察される．

Introduction

Consideration of various factors, with regard to the effectiveness of the insectides, is very essential in making recommendations for their use. Temperature is one of the factors which has a marked influence on the lethal action of the insecticides. Several workers have reported significant differences in the toxicity of the insecticides resulting from their use at different temperatures. A general survey of these papers indicates either a negative or a positive temperature coefficient of insect mortality to various insecticides. A positive temperature coefficient is shown when an increase occurs with a rise in temperature (Richards and Cutkomp, 1946; Hofman *et al.*, 1949; Hoffman and Lindquist, 1949) and negative one when a decrease occurs (Lindquist *et al.*, 1945; Richards and Cutkomp, 1946; Fan *et al.*, 1948 Hoffman and Lindquist, 1949; Yates, 1950; Vinson and Kearns, 1952; Roth *et al.*, 1953). In continuation of these researches the present authors conducted experi ments on the toxicity of DDT, Dieldrin and BHC against susceptible and resistant strains of houseflies at different temperatures in order to test the possible explanation of the occurrence of the temperature coefficient of insect resistance to insecticides. These insecticides were particularly choosen because of their extensive use in many environments having a wide range of temperature, supposed to influence a given species of insect in various parts of the world.

Material and Method

The housefly, *Musca domestica nebulo* was used as the test insect. The susceptible and the resistant flies were reared in the laboratory. The stock culture of the susceptible flies has never been exposed to any insecticide, while the resistant flies were obtained from the parent susceptible stock with the selection of resistant individuals by exposure to various insecticides for approximately 50 generations. For convenience these flies will be refered to hereafter as S for susceptible strain; A, B, and C respectively for DDT, Dieldrin and BHC resistant strains. All the strains utilized in the experiment were reared on milk soaked in cotton at a temperature of 28°±1°C and humidity between 70～80%. The insecticides used were pure DDT, Dieldrin and BHC obtained from Shell International Chemical Company, London. These were used as Acetone solutions.

The experimental technique, as adopted, mainly consisted of topical application of the insecticide to the houseflies and recording their percentage mortality after 24 hours. The 4-day old flies were anaesthetized with CO_2 and were tested by applying .002 cc of the formulation to the dorsum of the thorax through a screw-driven syringe. Each insecticide was applied in a range of three suitable concentrations. Three replications each of 40～50 individuals were tested on each of the concentrations. Clean tissue paper cages 4 inch in diameter were used as containers for the flies after the insecticidal applications. Sugar in the form of cubes were given as food to these flies. The flies were then taken to incubators maintained at 5°C, 15°C, 25°C and 35°C with relative humidity between 70～80%. At the end of 24 hours, mortality counts were recorded. The LC_{50} values of the insecticides at each temperature were determined with the aid of log-concentration mortality regression lines.

Results

The results obtained with each insecticidal application against the susceptible and the resistant flies at different temperatres are presented in the table. The data includes the toxicity responses pooled from a series of three different toxicity experiments on the houseflies. These were plotted

Table 1. Percentage mortality and LC_{50} of susceptible and resistant strains of houseflies exposed to DDT, Dieldrin and BHC at different post-treatment temperatures.

Strain	Insecticide	Concentration	Post-treatment temperature							
			5°C		15°C		25°C		35°C	
			% Kill	LC_{50}	% Kill	LC_{50}	% Kill	LC_{50}	% Kill	LC_{50}
S	DDT	0.125	35.7	0.28	31.0	0.39	21.2	0.64	26.2	0.47
〃	〃	0.5	57.4		52.2		46.6		51.3	
〃	〃	2.0	88.2		81.6		71.9		75.7	
〃	Dieldrin	0.125	31.2	0.35	35.3	0.26	40.7	0.2	49.6	0.12
〃	〃	0.5	55.4		61.7		70.9		86.9	
〃	〃	1.0	71.8		77.4		88.0		93.7	
〃	BHC	0.03125	28.7	0.046	24.0	0.052	15.2	0.077	21.4	0.06
〃	〃	0.0625	68.7		60.2		40.3		46.1	
〃	〃	0.125	93.4		85.9		71.4		80.8	
A	DDT	0.5	7.6	130.0	6.4	150.0	4.8	210.0	5.3	170.0
〃	〃	2.0	16.1		13.7		9.6		11.2	
〃	〃	6.0	22.7		19.5		15.1		17.1	
B	Dieldrin	0.125	7.6	1.2	3.7	1.05	11.1	0.74	15.3	0.47
〃	〃	1.0	42.2		49.5		59.2		69.2	
〃	〃	4.0	77.5		81.4		87.5		96.0	
C	BHC	0.125	31.2	0.26	26.4	0.37	23.1	0.54	25.1	0.44
〃	〃	1.0	81.2		73.5		62.2		66.5	
〃	〃	4.0	96.5		91.8		85.6		88.0	

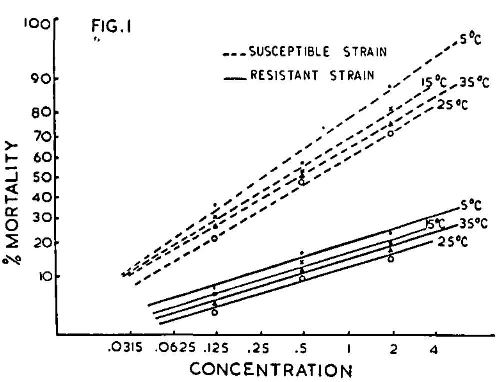

Fig. 1. Dosage-mortality regression lines for susceptible and resistant strains of houseflies exposed to DDT at different post-treatment temperatures.

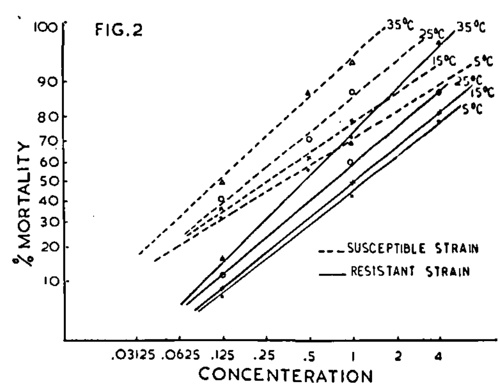

Fig. 2. Dosage-mortality regression lines for susceptible and resistant strains of houseflies exposed to Dieldrin at different post-treatment temperatures.

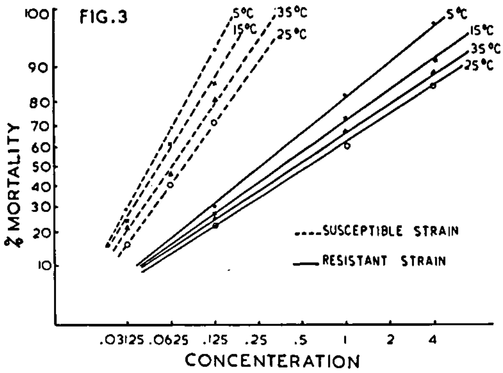

Fig. 3. Dosage-mortality regression lines for susceptible and resistant strains of houseflies exposed to BHC at different post-treatment temperatures.

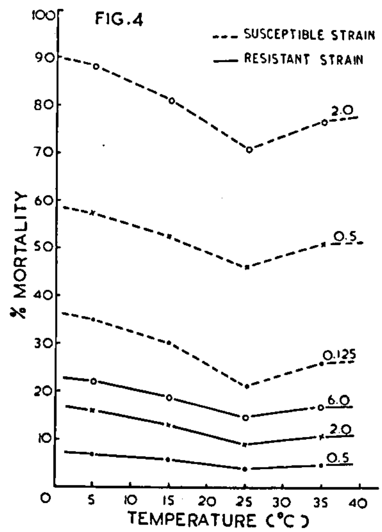

Fig. 4. Effect of temperature on the mortality of susceptible and resistant strains of houseflies exposed to different concentrations of DDT.

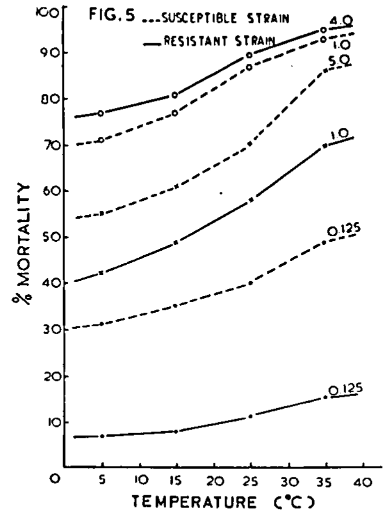

Fig. 5. Effect of temperature on the mortality of susceptible and resistant strains of houseflies exposed to different concentrations of Dieldrin.

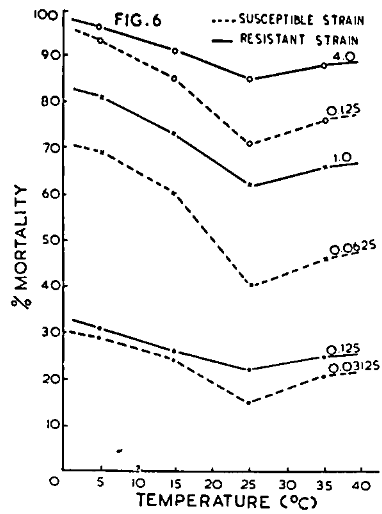

Fig. 6. Effect of temperature on the mortality of susceptible and resistant strains of houseflies exposed to different concentrations of BHC.

on log-concentration probit mortality graphs, and regression lines were drawn to determine the LC_{50} values (Figs. 1, 2 and 3). Besides the usual log-concentration probit mortality graphs, temperature mortality percentage graphs for different concentrations of the insecticides have also been given (Figs. 4, 5 and 6).

Discussion

It has already been described that an increase in the post-treatment temperature within the range where it exerts no lethal effect would either increase or decrease the toxic effect of the insecticide. The graphs obtained by plotting different values against temperaure under which they were recorded showed similar trends. Dieldrin gave a positive temperature coefficient *i. e.*, percentage mortality continued to increase with the increase in temperature. The reverse was found to be true with DDT and BHC which indicated negative temperature coefficient of mortality.

The positive temperature coefficient of mortality of S and B strains observed in case of Dieldrin is explained firstly on the basis of increased metabolism or increased chemical action at higher temperature and secondly on the basis of quicker penetration of the insecticide into the housefly or quick arrival of the insecticide at the site of action at higher temperature. On the other hand, the negative temperature coefficient of insect mortality exhibited by DDT and BHC to S, A and C strains is explained partly on the basis of increased physiological resistance in the housefly to the insecticides at higher temperature and partly due to the physical and chemical factors such as greater detoxification of the insecticides in the housefly at higher temperature.

It is generally known that greater amount of the toxicant penetrates the cuticle at high temperature, probably because of the increased chemical reactivity or solubility; but the small amount of the insecticide penetrating the cuticle at low temperature is more effective owing to the decreased metabolism, which gives comparatively high mortality at low temperature. This generalization has been realized during the present study because highest mortality was recorded at 5°C. As temperature continued to increase a decrease in mortality from 5°C to 25°C was indicated. The greater survival of the flies with the increase in temperature was probably due to the increase in metabolism, and consequently more rapid degradation of the insecticide. This upward trend of resistance would have probably been continued beyond 25°C, but an increase in temperature means also an increase in the activity of the housefly resulting in the quick arrival of the insecticide at the site of action which tends to bring about a positive temperature coefficient of mortality.

So far susceptible and resistant strains were concerned, their temperature coefficient almost remained the same. The only difference being in the time of onset of sysmptoms of toxic actions. Susceptible flies become agitated almost at once after the insecticidal applications at 5°C, the symptoms lasted for many hours and mortality continued to increase with the time. Resistant flies were affected slowly. Low temperature was more effective on increasing kill of the susceptible flies than with the resistant ones; and high temperature gave more added protection to the resistant flies than the susceptible flies.

Summary

The effects of temperature on the toxicity of DDT, Dieldrin and BHC applied topically to the susceptible and the resistant strains of houseflies have been determined. Dieldrin shows a positive temperature coefficient of mortality *i. e.*, mortality of the housefly continues to increase with the increse in temperature. On the other hand, DDT and BHC both indicate a negative temperature coefficient *i. e.*, the mortality of the housefly falls with the rise of temperature. Susceptible and resistant flies respond towards changing temperatures in a similar manner. As a possible explanation, for such divergent results with different insecticides, it is suggested that inherent physiological resistance and activity of the housefly are the two factors which regulate the rise and fall of the toxicity of the insecticides.

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